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THESIS

FINANCIAL STRENGTH AS A PREDICTOR
OF PRICING STRATEGY

by

Paul B. Webb

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Financial Strength as a Predictor of Pricing Strategy

by

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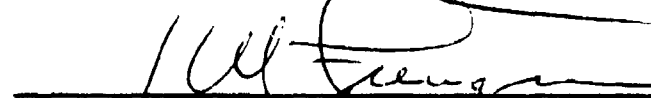December 1987

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ABSTRACT

The purpose of this research is to determine if the pricing strategy used by defense aerospace contractors can be explained using information readily available from the financial statements of the corporation and from compilations of industry financial data. The sample includes seventeen defense contractors within the aerospace industry and fifty-two aircraft and missile programs. Twenty-one financial ratios were developed from corporate financial data and compared with the industry average for the same ratio. The resulting values were correlated with the slope of the price reduction curve for the programs. A seven variable linear regression model was developed which is significant in explaining pricing strategy.

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I. INTRODUCTION

A. BACKGROUND

The Department of Defense (DOD) is the largest and most complex organization in the world, employing more than three million people, operating more than 5,600 installations around the world, and executing more than 15 million contracts per year with some 300,000 contractors. [Ref. 1:p. 1]

By anyone's measure the Department of Defense is big business. And large amounts of money pass through the contracting shops each day as 53,000 contract actions per day are completed. When dealing with that many contract actions even well trained, conscientious contracting officers will make mistakes. These mistakes are seldom due to fraud or gross neglect, but even so, the press reports the errant contract action across the country and the acquisition process gets another black mark against it. The President's Blue Ribbon Commission on Defense Management found that:

1. Americans consider waste and fraud in defense spending a very serious national problem and one of major proportions. On average, the public believes almost half the defense budget is lost to waste and fraud.

2. Americans believe that fraud (illegal activity) accounts for as much loss in defense dollars as waste (poor management).

3. While anyone involved in defense procurement is thought likely to commit fraudulent and dishonest acts, defense

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contractors are widely perceived to be especially culpable for fraud in defense spending. [Ref. 2:p. 76]

With this public mistrust of the acquisition process so pervasive and evident it is incumbent on the contracting officer to ensure that every action is taken in accordance with the letter and spirit of the law and that there is complete documentation of all actions. One of the ways contracting officers are accomplishing this is by increased use of certified cost or pricing data that the contractor submits in support of his proposal. But only items of fact have to be certified to, and this leaves plenty of judgmental items that the contracting officer must decide the adequacy and fairness of, knowing that his judgment could be called into question at any turn of the process. The contracting officer needs additional objective tools and procedures that he can rely on to help him make his decisions and to help him prove that the decisions were proper. This research is aimed at providing such a tool.

B. OBJECTIVE

The objective of this research is to investigate the possible presence of a relationship between a corporation's financial condition and its pricing strategy.

C. RESEARCH QUESTION

Does an identifiable and predictable relationship exist between product pricing strategy and reported corporate financial condition in the DoD aerospace industry?

1. What is pricing strategy and how is it related to the price reduction curve?

2. What is financial condition and how can financial condition be measured?

3. How are pricing strategies related to financial condition?

D. SUMMARY OF FINDINGS

The purpose of this research was to determine if pricing strategy for products in the defense aerospace industry could be predicted based on a firm's financial condition as measured by financial ratios compared against an industry average. The sample for this research included 17 defense aerospace contractors and 52 aircraft and missile programs.

The general approach was to test for associations between the price reduction curve, used to reflect pricing strategy, and measures of financial condition. These measures of financial condition were designed to capture the firm's financial status relative to the status of the firm's industry. The statistical methods used were the following: a correlation analysis of the financial measures, various regression analyses to develop and evaluate potentially explanatory

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models, and a factor analysis and regression analysis of the factors that were developed to produce an additional potentially predictive model.

The results were that a significant portion of the variance in the price reduction curve can be explained by financial condition as measured against industry averages.

E. ORGANIZATION OF STUDY

Chapter II discusses the background conceptual and theoretical framework including: pricing strategy and a basic explanation of learning curve theory and its use to operationalize the concept of a price reduction curve; along with Greer's [Ref. 3] efforts relating interperiod cost allocation methods and price reduction curve slope with pricing strategy; a study by McGrath and Moses [Ref. 4] relating financial condition to the slope of the price reduction curve for programs in the DoD aerospace industry; and research by Johnstone and Keavney [Ref. 5] into financial condition and pricing strategy.

Chapter III addresses financial condition, including the use of industry averages as a measure of financial condition, and describes the hypothesized relationship between financial condition and pricing strategy

Chapter IV describes the sample used in the analysis and the database.

Chapter V describes the analysis of the relationship between financial condition and pricing strategy. Results from univariate correlation tests, stepwise regression models, heuristically developed regression models, and a factor analysis and regression model are described and presented.

Chapter VI provides the conclusions of the research, a comparison of results with prior studies, and recommendations for further study.

II. BACKGROUND AND THEORETICAL CONCEPTS

A. INTRODUCTION

This chapter discusses the underlying conceptual and theoretical framework of the study. It begins with a discussion of pricing strategy and the learning curve, which is used to operationalize the price reduction curve. Following is a discussion of the previous work of Dr. Greer in "Early Detection of a Seller's Pricing Strategy" [Ref. 3], the work of McGrath and Moses presented in "Financial Condition and Contractor Pricing Strategy" [Ref. 4], and the research of Johnstone and Keavney in the Naval Postgraduate School thesis "Pricing Strategy, Pricing Stability and Financial Condition in the Defense Aerospace Industry" [Ref. 5].

B. PRICING STRATEGY

There are essentially two pricing strategies that can be pursued by companies. These strategies are; penetration and skimming. [Ref. 6:p. 174] Penetration pricing is defined as charging low prices to penetrate mass markets while discouraging others from entering the market. Skimming is defined as a policy of high initial prices that skim the cream of demand; price is lowered only as short-run competition forces it down. Penetration pricing depends upon

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economies of scale and progression down the learning curve to
achieve increased future profits.   [Ref. 7:p. 195]

Dean lists four reasons why a producer might choose a
skimming pricing strategy.

1. Sales of the product are less sensitive to price in the beginning
    because there are no competitors.

2. Starting with a higher price permits the seller to skim the
    cream of the market and then reduce the price to tap
    successively larger portions of the market.

3. The skimming policy is safer. By skimming, the seller is
    certain to cover costs of production early in the product life
    when production efficiencies are difficult to predict.

4. Skimming results in a large inflow of funds to finance the
    expansion necessary to tap the larger markets. [Ref. 6:pp.
    174-175]

There are also several reasons why penetration might be
chosen.

1. When sales volume is very sensitive to price.

2. When substantial economies of scale can be realized in the
    manufacturing and distribution.

3. When the product faces strong competition soon after
    introduction as in a competitive teaming arrangement.

4. When there is no elite class of buyer willing to pay the high
    price. [Ref. 6:p. 175]

In addition to the reasons listed above, timing and risk concerns
may influence the choice of pricing strategy. The penetration
strategy, since it entails lower prices and depends on economies of

scale to reduce costs and provide a return, will necessarily mean delaying profits into the future. Skimming, on the other hand, results in maximum profits being earned in the short run. Skimming also minimizes many of the risks associated with introducing a product. Since profits are maximized in the short run, a loss of market share to a competitor, cancellation of the product or other event that impacts on the earnings is less grievous. A company choosing penetration pricing is running a larger risk that some event will occur early in the project that will impact on the earnings stream and limit the company's ability to recover costs associated with introducing the product.

Greer discussed the interests of the buyer and the seller regarding pricing strategy. Early buyers will seek out a seller choosing penetration. Late buyers will seek out skimmers who are way down the price reduction curve. Skimmers will fear that buyers will delay purchases until the price declines. Penetrators fear that competitors will recognize the flat price reduction curve and be encouraged to enter the market. Clearly, pricing strategy will be a closely guarded secret. [Ref. 3:p. 7]

Penetration and skimming can be described in terms of the price of the first unit sold and the slope of the price reduction curve. Skimmers exhibit a high first unit price and a steep price reduction

curve. Penetrators exhibit a low first unit price and a flat price reduction curve. Neither strategy is inherently more profitable. Skimming achieves greater profits early on and penetration stretches out the profits. [Ref. 3:pp. 6-7]

C. LEARNING/PRICE REDUCTION CURVE

The learning curve concept originated with the observation that individuals performing repetitive tasks tend to exhibit a trend of improvement. Because the learning curve applies not only to the actual manufacturing process but also to materials handling and use, scrap rates, tool usage, etc., it can be more generally referred to as a cost reduction curve. A per-unit reduction can be extended conceptually to the measure of price per unit. Thus, the learning curve can be used to operationalize the concept of the price-reduction curve.

A common mathematical expression for the learning curve is:

$$C = AX^B$$

or in log form,

$$\ln C = \ln A + B \ (\ln X)$$

where C is the price of the Xth unit produced and A is the price of the first unit produced. The exponent, B, must be negative if price is to decline with experience. If B were zero every unit produced

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would be priced at A. If B were positive, C would grow with experience.

The slope of the learning curve (S) is related to B as follows:

$$B = \frac{\ln S}{\ln 2}$$

A slope of 1.00 would indicate a horizontal price reduction curve. The lower the decimal value of the slope, the higher the price reduction rate. A slope of .800 is steeper than a slope of .900. Slopes of .800 to .900 are common for complex, high technology products such as the aircraft and missiles included in this study.

D. GREER ARTICLE

Dr. Willis R. Greer, Jr., a professor of accounting at the Naval Postgraduate School, demonstrated a strong relationship between contractor accounting method choices and the slope of the price reduction curve for programs in the defense aerospace industry. [Ref. 3] He felt that the major pricing strategies pursued, skimming and penetration, would be reflected in the price reduction curve. Skimming, which involves a high initial price with reductions over the life of the product would be reflected in a steep price reduction curve. Penetration on the other hand, would involve a low initial price with little reduction over the life of the product. This would best be reflected by a flat price reduction curve.

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He hypothesized that interperiod allocation of costs such as depreciation method and inventory valuation methods would be associated with the pricing strategy being pursued. Specifically, accelerated depreciation would cause a larger amount of cost to be allocated to early production units and would therefore result in a steeper price reduction curve. Likewise, the LIFO inventory method, when chosen in an inflationary environment, would cause an early recognition of the cost of materials. This again should be associated with a steeper price reduction curve.

His data base consisted of eleven contractors and 31 programs from the defense aerospace industry. His best linear regression model, removing outliers from the data base, resulted in an R-squared value of .917 for the model with a t-ratio of +6.33 for the depreciation variable and +3.59 for the inventory variable. This would tend to confirm his hypothesis that interperiod allocation of costs will be indicative of pricing strategy

This early research connecting accounting methods with the slope of the price reduction curve provided the impetus for later studies of financial condition and the slope of the price reduction curve.

E. MCGRATH/MOSES ARTICLE

O. Douglas Moses, assistant professor of accounting at the Naval Postgraduate School and Captain Kurtis McGrath, USMC published an article in Program Manager magazine on "Financial Condition and Contractor Pricing Strategy" [Ref. 4]. This detailed the results of a study they conducted relating financial condition, as expressed through financial ratios, to the slope of the price reduction curve. They hypothesized that the skimming or penetration pricing strategy would be preferred depending on internal factors related to financial condition.

Their data base consisted of 35 programs from the defense aerospace industry. They identified five areas of financial condition as being important. These were profitability, liquidity, solvency, activity, and investment. Twenty three common financial ratios covering the five areas were developed for the year prior to program start for each program. Correlation and regression analyses were conducted and a model was developed reflecting the relationship between financial condition and the slope of the price reduction curve. This model included six of the ratios and had an adjusted R-squared value of .539. The ratios included were: the current ratio, the receivables turnover ratio, the current debt ratio, the interest coverage ratio, the inventory turnover ratio and the

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investment to funds ratio. All of the ratios could be viewed as involving measures of current assets and current liabilities. No ratio from the profitability category was included. Overall, their findings suggest that measures of risk and asset utilization are factors influencing pricing strategy.

F. JOHNSTONE/KEAVNEY STUDY

Lieutenants Johnstone and Keavney, in their masters thesis at the Naval Postgraduate School [Ref. 5], conducted further analysis into the relationship between financial condition and the slope of the price reduction curve in the defense aerospace industry. Like McGrath and Moses, they hypothesized that pricing strategy was influenced by factors relating to financial condition and could be determined by predicting the slope of the price reduction curve. Their study specifically looked at financial ratios in earlier years and included data from the year of program start and for the five years prior to that.

They examined 17 contractors working on 52 aircraft and missile programs. Financial ratios covering profitability, short term liquidity, solvency, asset utilization and investment were developed and then correlation and regression analyses were used to relate the 18 financial ratios to the price reduction curve. They concentrated on the third year prior to program start and developed a four

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variable model that included ratios from all but the solvency category. The model had an adjusted R-squared value of .3445.

They also examined the changes in ratios from year to year using the same financial ratios and methods. This resulted in a two variable model that had an adjusted R-squared value of .41. However only one category of financial ratios was included and both ratios were effectively constructs of the same information. They concluded that there was some relationship between financial condition as reflected by financial ratios but that the methods they had tried to quantify that relationship had been largely unsuccessful.

G. CONCLUSION

Manufacturers can be expected to price their products using either a penetration or a skimming pricing strategy. Pricing strategy can be described by using the first unit price and the slope of the price reduction curve. Previous studies have indicated that there is a relationship between financial condition and the slope of the price reduction curve.

This study will extend the research begun by McGrath/Moses and Johnstone/Keavney. The database used will be substantially that of Johnstone and Keavney. The categories of financial condition will be the same five as were used in both the studies listed above.

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Both the McGrath/Moses and Johnstone/Keavney studies used unadjusted financial ratios to reflect financial condition. Yet sample projects investigated in the studies spanned three decades during which industry conditions may have changed. Hence, unadjusted financial ratios taken at widely different points in time may not be comparable in their meaning for financial conditions.

This study will first relate the firm's financial condition to that of the industry in general. Then the general statistical methods used in previous studies will be employed. Finally, a factor analysis will be attempted and a regression analysis will be done using the factors derived from the factor analysis as the variables.

III. FINANCIAL CONDITION AND PRICING STRATEGY

A. INTRODUCTION

This chapter begins the detailed analysis of financial condition and pricing strategy. It begins with a discussion of financial condition, including the financial ratios used in this study, and then considers possible relationships between financial condition and pricing strategy.

B. FINANCIAL CONDITION

A corporate annual report usually consists of a balance sheet, income statement and statement of changes in financial position. The balance sheet, or statement of financial position, shows the firm's assets, liabilities and owner's equity, usually for both the current and previous year. The income statement shows revenues, expenses and net income for the period. The statement of changes in financial position shows where funds came from during the year and what the funds were used for. Taken together these statements present a financial picture of the firm. [Ref. 8:pp. 163-164]

Financial statements may be difficult to interpret in their raw form. For example, what can be determined about profitability by looking at the net income of a firm? Very little in fact, but, by

comparing the net income with the assets or capital required to generate the income some feeling can be gotten for the efficiency of operations and the financial condition of the firm.

The financial condition of a firm is most often expressed through the use of financial ratios. The raw financial data provided by a company in its annual report can be analyzed by the use of ratio analysis to determine the current status of the company.

1.   Financial Ratios

It is possible to calculate a nearly endless number of financial ratios from the financial statements. It was felt that five categories of ratios were required to reflect adequately the financial condition of a company. These five categories are:

1.   Profitability

2.   Short term liquidity

3.   Solvency

4.   Asset utilization

5.   Capital investment.

These categories are consistent with those used in the previous studies discussed in Chapter II. The categories, and the ratios used, are discussed below.

2. Profitability

The operating activities of a company are carried out in order to generate a profit. The measures of profitability reflect the success of these endeavors. Three ratios commonly used to measure profitability are:

1. Profit margin
2. Return on assets
3. Return on equity.

Profit margin reveals the profit earned per dollar of sales and thus is a measure of the efficiency of the operation. Return on assets relates operating profits to assets available to earn a return and shows how well a firm is employing its assets. Return on equity is used to analyze the ability of the firm to realize an adequate return on the funds invested by the owners of the firm. [Ref. 9:p. vi]

3. Short Term Liquidity

Short term liquidity measures the ability of the firm to pay its debts in the near term. The measures of liquidity included in this study include:

1. Current ratio
2. Quick ratio
3. Current assets ratio
4. Receivables turnover

5. Cash ratio

6. Working capital ratio.

The current ratio measures how well current assets cover current liabilities. It also shows the margin of safety available to cover any possible shrinkage in the value of current assets. [Ref. 9:p. v] The quick ratio reveals the protection afforded short term creditors in cash or near-cash assets. It shows the number of dollars in liquid assets available to cover each dollar of current debt. [Ref. 9:p. v] The cash ratio compares the most liquid assets, (cash and marketable securities), with the current liabilities. The current assets ratio shows the quantity of liquid assets as compared to the total assets of the firm. The receivables turnover ratio provides an indication of the how rapidly the accounts receivable are converted into cash. [Ref. 10:p. 220] The working capital ratio relates the excess of current assets over current liabilities to total assets.

4. Solvency

Solvency measures show the ability of the firm to meet interest and principal payments on long term debt. The measures of solvency included in the study are:

1. Debt ratio

2. Current debt ratio

3. Debt to equity ratio

4. Current debt to equity ratio.

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The debt ratio shows the portion of the firms long term capital that is provided by debt holders. The current debt ratio shows the portion of the firms assets that are funded by short term creditors. The debt to equity ratio contrasts the funds that owners provide with the total funds that creditors and debt holders provide. The current debt to equity ratio contrasts the funds that creditors are temporarily risking with the funds permanently invested by the owners.

5. Asset Utilization

Asset utilization ratios help illustrate how efficiently a firm uses its assets. The asset utilization ratios included in this study are:

1. Total assets turnover
2. Plant assets turnover
3. Inventory turnover
4. Working capital turnover.

Total assets turnover shows the degree to which sales are generated per dollar of total assets. The plant assets turnover ratio is a measure of the relationship between sales and the investment in plant assets such as plant, property and equipment. Inventory turnover relates sales to inventory on hand and is considered to be a significant indicator of the efficienc operations for many

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companies. The working capital turnover ratio relates sales to working capital and measures the length of the operating cycle of the firm or the length of time from the purchase of materials on account through manufacture and sale of the goods to payment of the suppliers. [Ref. 10:pp. 220-222]

6. Capital Investment

The capital investment ratios used in this study were:

1. Investment to assets

2. Investment to plant assets

3. Investment to sales

4. Investment to funds.

These capital investment ratios relate new dollars of investment in productive capacity to existing assets or other measures of firm size.

7. Ratio Selection

This study made use of all the ratios discussed above. These ratios and their computational formulas are listed in Table 1. The ratios were chosen for one of two reasons. First, the standard ratios discussed in the accounting literature as being useful for describing the financial condition of a company were included if they could be calculated from the information available. Several ratios, such as interest coverage, were eliminated from the study due to this last requirement. Other, less commonly used, ratios were

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TABLE 1

FINANCIAL RATIOS

Profitability

Profit margin = net income/sales

Return on assets = net income/total assets

Return on Equity = net income/stockholders equity

Short Term Liquidity

Current ratio = current assets/current liabilities

Quick ratio = (current assets − inventories)/current liabilities

Current asset ratio = current assets/total assets

Receivables turnover = sales/accounts receivable

Cash ratio = (cash + marketable securities)/current liabilities

Working capital ratio = $\dfrac{\text{(current assets − current liabilities)}}{\text{total assets}}$

Solvency

Debt ratio = total liabilities/total assets

Current debt ratio = current liabilities/total assets

Debt to equity = total assets/stockholders equity

Current debt to equity = current assets/stockholders equity

Asset Utilization

Total asset turnover = sales/total assets

Plant asset turnover = sales/plant & equipment

Inventory turnover = sales/inventory

Working capital turnover = $\dfrac{\text{sales}}{\text{current assets − current liabilities}}$

Capital Investment

Investment to assets = investment/total assets

Investment to plant = investment/plant & equipment

Investment to sales = investment/sales

Investment to funds = investment/net income

included because they had been found useful in previous studies utilizing financial ratios [Ref. 11:pp. 51-59]. Overall, the selection of the twenty-one ratios was felt to be reasonably inclusive of the factors determining financial condition.

C. INDUSTRY AVERAGES

Financial condition expressed in terms of financial ratios has little significance except when it is compared to some appropriate standard. Some ratios have "rules of thumb" associated with them. For example, the current ratio is considered good if it is at least 2, the quick ratio should be at least 1, and a return on equity of at least 10% is considered desirable [Ref. 9:pp. v-vi]. However, for the majority of financial ratios, comparison to some standard will be the best way to interpret the ratio. There are several possible standards for comparison. They include:

1. Mental standards of the analyst, i.e., a general conception of what is adequate or normal which has been gained by his personal experience and observation.

2. Ratios and percentages based on the records of the past financial and operating performance of the business.

3. Ratios and percentages of selected competing companies, especially the most progressive and successful ones.

4. Ratios and percentages developed by using the data included in the current budgets. Such ratios would be based on the individual company's past experience modified by anticipated changes during the accounting period. These ratios would properly be called "goal ratios."

5. Ratios and percentages of the industry of which the individual company is a member. [Ref. 12:p. 297]

Because each industry has its own characteristics which influence the operating and financial characteristics, industry ratios are particularly valuable in measuring the performance of a particular company within an industry. Without information as to what is an adequate or favorable ratio in the industry, it is more difficult to evaluate the financial condition of a company [Ref. 12:p. 298]

The industry average was chosen as a basis of comparison for the purposes of this study. Specifically, the industry was defined as being covered by the standard industrial classification codes 372X, aircraft and parts, and 376X, guided missiles, space vehicles and parts.

Financial ratios for an industry as a whole or for identifiable segments of an industry are available from commercial concerns such as Dun & Bradstreet or Robert Morris Associates or from industry trade associations such as the Aerospace Industries Association of America (AIAA).

D. FINANCIAL CONDITION AND PRICING STRATEGY

Recalling the five categories of financial ratios that describe financial condition, there is reason to believe that financial condition, as reflected by the ratios, could be related to pricing

strategy. For example, McGrath and Moses believe that firms that have high profitability should prefer skimming. This is because executives are frequently compensated on the basis of profits and may prefer early recognition of profits. Therefore, the presence of high profitability measures before introduction of an item may indicate the continuing demand for high-profit projects in the short run. [Ref. 4:pp. 12-13]

Similarly, in the area of short term liquidity, skimming may be the strategy preferred by firms lacking short term funds. This is due to the faster payback offered by skimming. Introduction of a product can result in short term fund shortfalls so a poor liquidity position prior to introduction of a product could motivate a skimming pricing strategy. [Ref. 4:p. 13]

The area of solvency has arguments analogous to those presented above for short term liquidity. Additionally, producers in the DoD aerospace industry face considerable risk that the progrm life may be cut short. Skimming, by returning profits early, reduces that risk. Therefore, firms that are in a poor solvency position (more debt and higher risk) are expected to prefer skimming. [Ref. 4:p. 13]

The available capacity of a manufacturing firm may also influence pricing strategy. Firms with limited unused

manufacturing capacity may prefer to approach a small market with a high price, i.e., skim. Firms with significant amounts of unused capacity may prefer to penetrate and thereby employ all of their available capacity. Asset utilization measures reflect the level of sales generated on assets and consequently reflect the degree to which assets are adequately employed. Therefore firms with low asset utilization levels may desire to increase asset utilization and might therefore tend to prefer penetration. Firms with high asset utilization levels may be unable to expand production to penetrate a market and would therefore be motivated to skim. [Ref. 4:p. 13]

Asset utilization measures the current use of available assets. Capital investment ratios measure the investment being made to various assets for future use. An expansion of assets may indicate an intention to expand future production. The need to make full use of the expanded capacity may motivate a penetration strategy. So, high capital investment ratios may be associated with a penetration strategy. Low capital investment ratios would therefore be indicative of a skimming strategy. [Ref. 4:p. 13]

E. CONCLUSION

Financial condition can be explained through the use of financial ratios, particularly when the ratios are compared to an appropriate base. There are likely to be factors internal to the company related

to financial condition that may result in preference for one pricing strategy over another. These factors should be reflected in the financial condition of the firm and should relate to the slope of the price reduction curve.

IV. SAMPLE SELECTION AND DATA COLLECTION

A. INTRODUCTION

This chapter will describe the following:

1. The process used to select the aircraft and missile programs used in the study.

2. The data items from the specific programs required for the statistical analysis.

3. The financial data elements required for the years of each program studied, their sources and their availability.

4. The industry averages for financial ratios used in the study, their sources and their availability.

B. SELECTION PROCESS

Data on aircraft and missile programs were found in two sources. These were the U.S. Military Aircraft Cost Handbook [Ref. 13] and the U.S. Military Missile Cost Handbook [Ref. 14]. These sources provided the following necessary information:

1. Aircraft and missile identification

2. Manufacturer identification

3. Slope of the unit cost curve

4. Year of program start. [Refs. 13,14]

Aircraft and missile programs were selected for this study based on the availability of the slope of the unit cost curve for the

airframe. It was decided to use the data associated with the airframe costs rather than the total flyaway costs because of the assumption that the airframe is produced totally by the prime contractor. Avionics, engines, armament and test equipment are frequently procured from subcontractors or are provided as government furnished equipment (GFE). Programs chosen were limited to those that were produced by publicly held companies because of the difficulty in acquiring financial data from privately held companies.

Table 2 presents the firms, programs, and the years the programs were active. It includes seventeen contractors and fifty-two programs.

C. FINANCIAL STATEMENT ELEMENTS

Financial data for the companies listed were obtained from the annual financial reports, from 10K reports filed with the Securities and Exchange Commission or from Moody's Industrial Manuals. The elements that were used are shown in Table 3. This information was collected for each program for the year of program start and for the five years prior to that.

Available data was used to calculate the "new investment in plant & equipment" (NIPE) figure. This was calculated using the formula:

TABLE 2

LIST OF CONTRACTORS AND PROGRAMS

Manufacturer	Program	Year Started	Year Ended
Chance-Vought	A-7A/B	65	67
	A-7D	68	75
	A-7E	67	79
	F-8A/B/C	55	58
	F-8D/E	58	63
Motorola	AIM-9C	61	67
Bell	AH-1S	75	80
	AH-1T	76	78
Bendix	RIM-8E	61	66
North American	F-1B/C/MF-1C	52	55
	F-100C	53	55
	F-100D	54	56
	F-86D	51	53
	F-86F	51	53
McDonnell Douglas	F-15A	73	79
	A-4M	70	77
Douglas	F-6A	52	54
	A-3A/B	53	57
	B-66B	53	55
	A-1E/G/H	52	54
Northrop	F-89D	51	54
Lockheed	P-3A	60	64
	P-3B	65	67
	P-3C	68	82
	F-104A/B/C/D	56	57
Fairchild	A-10A	75	82

TABLE 2 (CONTINUED)

Manufacturer	Program	Year Started	Year Ended
Cessna	A-37B	67	73
Boeing	B-47B/E	49	53
	B-52G	57	59
Grumman	A-6A	61	69
	F-14A	71	82
	A-6E	70	79
Republic	F-84F	51	53
	F-105B/D	57	62
Martin	B-57B/C/E	52	55
Raytheon	AIM-7F	68	80
	AIM-7M	80	82
General Dynamics	RIM-2E	61	66
	RIM-66E	80	82
	RIM-20	61	64
	BGM-109	80	82
	RIM-92A	78	81
	RIM-67B	73	82
	RIM-66B	71	80
	RIM-67A	66	74
	RIM-66A	66	70
	RIM-24B	61	66
	F-102A	53	57
	F-106A/B	57	59
	F-16A	78	82
	FB-111A	67	69
	F-111F	70	74

TABLE 3

FINANCIAL DATA USED IN THE ANALYSIS

<u>Balance Sheet</u>

cash

accounts receivable

marketable securities

inventories

total current assets

plant and property assets

total non-current assets

total assets

current liabilities

total liabilities

total stockholder equity

<u>Income Statement</u>

sales

net income

<u>Miscellaneous</u>

new investment in plant and equipment

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$$NIPE = (Plant \& equip)_t - (Plant \& equip)_{t-1}$$

where:

t = period for which new investment in plant & equipment was being calculated, and t-1 = period immediately preceding t.

D. SOURCES OF INDUSTRY AVERAGES

The industry financial information used was obtained from the Aerospace Industries Association of America (AIAA). This was the only source available that had the information required back to the year 1946. The association has an Aerospace Research Center that compiles the data based on information obtained from the Department of Commerce. The financial elements used for the industry were identical to those listed for the companies in Table 3. The information available from AIAA included a reasonably detailed average balance sheet for the industry but the income statement included only certain accounts. Notably absent were figures for interest expense, depreciation and cost of goods sold. This resulted in the elimination from the analysis of some ratios that otherwise would have been included.

A problem with comparability exists for year 1960. Prior to that year the industry financial data was gathered using a base of twelve contractors. From 1960 to the present, the data has included

a base of 50 contractors. This affected only the calculation of the "new investment in plant & equipment" figure for 1960.

The industry financial data covers both aircraft manufacturers as well as guided missile manufacturers. The group standard industrial classification codes 372X (aircraft and parts) and 376X (guided missiles and space vehicles and parts) are included in the data provided by AIAA but are not segmented. The financial data for the industry as a whole is not as tailored as would have been desired but can still serve as a useful benchmark for comparison.

More current and complete industry financial data can be obtained from Dun and Bradstreet. The information available from this company is much more detailed than the AIAA information, particularly in the income statement accounts. The Dun and Bradstreet data is also broken down by standard industrial classification code and could be more tailored to the program being analyzed. However, the data is only available back through the late 1960s and therefore could not be used for this study which required data back to 1946.

E. FIRM/INDUSTRY RATIO COMPARISON

Two methods of comparing the company financial ratios with the industry average of the same ratio were used. The first method involved subtracting the industry average from the company

financial ratio. This resulted in values clustered about zero with values greater than one indicating that the company was better than the industry average and values less than one indicating that the company was below the industry average.

The other method used was to divide the company financial ratio by the industry average of the same ratio. This results in values clustered around one with values between zero and one indicating that the company is below the industry average and values greater than one indicating that the company is exceeding that particular industry average.

These measures created by the subtraction or division are measures designed to reflect contractor financial condition relative to the benchmark of industry financial condition. These measures are used in the analysis portion of this study as independent variables used to explain slopes of price reduction curves. For simplicity the term "ratio" will be used to refer to these measures, although the reader should remember that they are not raw ratios but rather measures created by comparison to industry norms.

V. DATA ANALYSIS

A. INTRODUCTION

This chapter describes the data analysis efforts undertaken. The objective was to identify any stable relationship between the financial data and the slope of the price reduction curve and to determine whether a predictive model could be developed.

The analysis consisted of the following parts:

1. Correlation analysis performed on the individual financial ratios for all of the years

2. Selection of a measure (subtraction or division) and a year for further analysis

3. Stepwise regression analysis of all the ratios for the chosen year

4. Development of several regression models created by heuristically choosing inputs for the models

5. Factor analysis and development of a regression model using the factors that were determined

B. CORRELATION ANALYSIS AND SIGNIFICANCE

Correlations were computed between the ratios and the slope of the price reduction curve. This was done for both the subtraction and division measures and for each of the six years of the study. The year of program start is referred to as year 0. The year prior to program start is year 1, etc. The objectives were:

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1. To determine the signs of the relationships between the ratios and the slopes of the price reduction curves

2. To check the statistical significance of the correlations and

3. To determine consistency of the relationships over time or any possible trends.

The results of the correlation analysis are presented in Table 4 for years 0 through 2 and in Table 5 for years 3 through 5.

Of the univariate correlations calculated for the 6 years of the study, 62 of the 126 values, or 49%, were statistically significant at the .10 alpha level. (This indicates that there was less than a ten percent probability that such a correlation would occur by chance.) The ratios which were significant over at least half the years of the study were:

Ratio	Years of Significance Subtraction	Division
Current Ratio	2,3,4,5	2,3,5
Quick Ratio	3,4,5	
Cash Ratio	2,3,4,5	
Debt Ratio		2,3,5
Total Asset Turnover		1,2,3
Investment to Assets		0,1,2
Investment to Funds	3,4,5	1,2,4

With the exception of the investment ratios all of the statistically significant ratios included years 2 and 3 for at least one of the two kinds of measures (subtraction or division). A list of the ratios that were statistically significant in both years 2 and 3 with their correlation coefficients follows:

TABLE 4

CORRELATION RESULTS FOR YEARS 0 THROUGH 2

Category/ Ratio	Predicted Sign	Correlation Coefficients					
		Yr 0		Yr 1		Yr 2	
		−	÷	−	÷	−	÷
Profitability/							
• Profit Margin	−	−.204*	−.202*	−.145	−.107	−.044	−.004
• Return on Assets	−	−.003	.005	−.097	−.107	.105	.010
• Return on Equity	−	−.084	−.091	−.022	−.020	.036	.032
Short Term Liquidity/							
• Current Ratio	+	.041	.042	.079	.082	−.296*	−.290*
• Quick Ratio	+	.008	.009	.009	.009	−.180	−.047
• Current Asset Ratio	+	.024	.026	−.013	−.039	−.053	−.066
• Receivables Turnover	+	−.025	−.031	−.243*	−.245*	−.138	−.153
• Cash Ratio	+	.004	.004	.003	.003	−.401*	−.252*
• Working Capital Ratio	+	.078	.072	.029	.019	−.250*	−.209*
Solvency/							
• Debt Ratio	−	−.015	−.010	.024	.014	.263*	.283*
• Current Debt Ratio	−	−.040	−.033	−.044	−.065	.259*	.277*

TABLE 4 (CONTINUED)

Category/ Ratio	Predicted Sign	Correlation Coefficients					
		Yr 0		Yr 1		Yr 2	
		−	+	−	+	−	+
•Debt to Equity Ratio	−	.035	.036	.021	.020	.130	.154
• Current Debt to Equity Ratio	−	.031	.024	.020	.018	.140	.170
Asset Utilization/							
• Total Asset Turnover	−	−.071	−.017	.133	.272*	.201*	.279*
• Plant Asset Turnover	−	−.013	.005	.024	.103	.099	.175
• Inventory Turnover	−	−.287*	−.271*	−.241*	−.221*	−.052	.012
• Working Capital Turnover	−	.091	.119	.053	.091	.351*	.389*
Capital Investment/							
• Investment to Assets	+	−.419*	.388*	−.369*	−.553*	−.138	.395*
• Investment to Plant	+	−.137	.155	−.244	−.445*	−.186	.356*
• Investment to Sales	+	−.080	.052	−.297	−.466*	.021	.334*
• Investment to Funds	+	−.051	.063	−.166	−.529*	−.079	.410*

*Indicates significant at the .10 alpha level (≤ .10)

TABLE 5

CORRELATION RESULTS FOR YEARS 3 THROUGH 5

Category/ Ratio	Predicted Sign	Correlation Coefficients					
		Yr 3 −	Yr 3 ÷	Yr 4 −	Yr 4 ÷	Yr 5 −	Yr 5 ÷
Profitability/							
• Profit Margin	−	−.256*	−.079	−.024	−.156	.075	−.106
• Return on Assets	−	−.107	−.130	−.015	−.129	−.006	−.084
• Return on Equity	−	−.102	−.116	.055	−.085	.072	.011
Short Term Liquidity/							
• Current Ratio	+	−.293*	−.244*	−.204*	−.178	−.280*	−.254*
• Quick Ratio	+	−.238*	−.017	−.327*	−.104	−.208*	−.071
• Current Asset Ratio	+	−.019	−.026	−.038	−.049	−.073	−.077
• Receivables Turnover	+	−.137	−.143	−.093	−.145	−.164	−.338*
• Cash Ratio	+	−.492*	−.201	−.411*	−.070	−.328*	−.285*
• Working Capital Ratio	+	−.268*	−.201*	−.132	−.086	−.174	−.103
Solvency/							
• Debt Ratio	−	.179	.239*	.014	.047	.178	.213*
• Current Debt Ratio	−	.187*	.225*	.088	.102	.132	.162

TABLE 5 (CONTINUED)

Category/ Ratio	Predicted Sign	Correlation Coefficients					
		Yr 3		Yr 4		Yr 5	
		−	+	−	+	−	+
•Debt to Equity Ratio	−	.053	.133	−.108	−.102	−.005	.055
• Current Debt to Equity Ratio	−	.078	.150	−.083	−.085	−.030	.031
Asset Utilization/							
• Total Asset Turnover	−	.297*	.283*	.170	.136	−.041	−.043
• Plant Asset Turnover	−	.040	.064	.020	−.004	−.061	−.029
• Inventory Turnover	−	.037	.103	−.019	−.005	−.014	.007
• Working Capital Turnover	−	.355*	.355*	.157	.065	−.089	−.073
Capital Investment/							
• Investment to Assets	+	−.091	−.131	.002	.249	−.298	.081
• Investment to Plant	+	.127	−.200	−.312	.119	−.047	−.007
• Investment to Sales	+	−.191	.100	−.111	.276	−.077	−.001
• Investment to Funds	+	−.368*	−.058	−.428*	.485*	.736*	−.239

*Indicates significant at the .10 alpha level (≤ .10)

		Correlation Coefficients		
	Subtraction		Division	
Ratio	Yr2	Yr3	Yr2	Yr3
Current Ratio	-.296	-.293	-.290	-.244
Cash Ratio	-.401	-.492		
Working Capital Ratio	-.250	-.268	-.209	-.201
Debt Ratio			.283	.239
Current Debt Ratio	.259	.187	.277	.225
Total Asset Turnover	.201	.297	.279	.283
Working Capital Turnover	.351	.355	.389	.355

It is important to note that the ratios that are significant in years 2 and 3 represent only three of the five categories of financial ratios that represent financial condition. The profitability and the capital investment categories are not consistently significant in years 2 and 3. Of the profitability ratios only profit margin has statistically significant values and these occur in year 0 for the subtraction and division measures and in year 3 for the subtraction measure only.

In examining overall numbers of statistically significant ratios years 2 and 3 are clearly the most important. For the subtraction measure year 2 had 7 significant values and year 3 had 9 significant values. Neither of these is over half of the total of 21 ratios examined. For the division method of comparison, year 2 had 11 significant values and year 3 had 6. Only year 2 of the division method had over half of the ratios significant. Year two of the division method also included significant values in all of the categories except profitability.

These univariate correlation tests indicate that there may be a relationship between financial condition and the slope of the price reduction curve. The strongest categories appear to be short term liquidity, asset utilization and capital investment. The strongest relationship appears to exist in year 2 or year 3 prior to program start. These two years seem to be the strongest candidates for inclusion in a predictive model.

C. OBSERVATION OF SIGNS

Whereas the significance of the correlation analysis indicated potential relationships between financial condition and the slope of the price reduction curve, an analysis of the signs of the correlation coefficients revealed that they did not always match the predicted signs. The sign predictions were based on the previous work of McGrath and Moses [Ref. 4]. For the 21 ratios used the actual results are listed below.

| | Number of Signs as Predicted | |
Year	Subtraction	Division
0	13	15
1	9	9
2	3	5
3	4	4
4	6	11
5	8	6

The fact that the signs do not tend to match the predicted signs clearly causes problems; particularly so since the years with the

highest numbers of significant correlation coefficients, years 2 and 3, are also the years with the fewest predicted signs in both comparison methods. The signs tended to match with greater frequency as the time to program start decreased, although year 4 of the division method is a significant anomaly. Other noteworthy aspects of the sign analysis are:

1. The signs for the short term liquidity ratios never matched the predicted sign until year 1 and then tended to match for years 1 and 0.

2. The profit margin signs for the division measure were the only ones that matched the predicted signs for all six years of the study.

3. The receivables turnover ratios were consistently opposite the predicted value for both methods and for all six years of the study.

In examining the relationship between the signs and the significance of the correlation coefficients it was found that 20% (5 of 30) of the statistically significant subtraction method ratios had predicted signs. This is as compared to the division measure in which 39% (9 of 32) of the statistically significant ratios had predicted signs.

The analysis of the signs was inconclusive. Clearly, the observed signs do not match the predicted signs in most cases and in the years with the highest correlation (years 2 and 3) the incidence of predicted signs is the least. This casts doubt on the hypothetical

relations between the ratios and the price reduction curve that were enumerated in Chapter III. The analysis was continued despite this problem.

D. CHOICE OF YEAR AND COMPARISON MEASURE

At this point in the analysis it was necessary to narrow down the years and comparison measures so that more detailed analysis could be conducted without the burden of unproductive or redundant data. The decision was made to drop the subtraction measure from further analysis. Within the division measure it was decided that year 2 had the most potential for use in developing a predictive model and all other years of the division measure were therefore dropped from the study. These decisions were made because the division measure had a greater number of statistically significant correlation coefficients (32 as compared to 30 for subtraction) and because it had a higher number of predicted signs. Year 2 was chosen because the greatest number of ratios had their highest correlation with the price reduction slope in year 2 (8 of 21) and because year 2 had the highest number of statistically significant values (11 of 32). Year 2 was chosen despite the fact that it had the second lowest number of ratios with predicted signs (5). The decision was made to go with the results of the correlation analysis because it reflected where the strongest relationship

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between financial condition and price reduction curve was likely to be shown. The observation of signs was held to be secondary because it reflected the hypothesis of why the relationship was to be expected. The hypotheses may be incorrect but the relationship could still be shown.

E. REGRESSION ANALYSIS

With year 2 selected for further analysis the study proceeded into the regression analysis phase. The purpose was to determine how much of the variability in the slope of the price reduction curve could be explained by the ratios and ultimately to build an explanatory model of the relationship. The first step taken was to run a forward stepwise regression. This was done to determine the significance of the various variables as predictors of the slope of the price reduction curve while controlling for the other variables. The resulting model is described by the equation:

$$slope = .743 + .0083X_1 + .1432X_2$$

where:

	t	sig t
X_1 = Investment to Funds	3.286	.0046
X_2 = Working Capital Turnover	3.206	.0055

The statistical values obtained for this model were:

R^2 = .49332
Adjusted R^2 = .42999
F-statistic = 7.789
Significance of F = .0043

The analysis stopped after the two variables were entered due to internal constraints of the program used. Experimentation showed that this occurred because of the capital investment ratios. For this reason the regression was then run without any of the capital investment ratios included. This was done to determine the relative significance of the variables other than the capital investment ratios so that these variables could be included in later heuristic models.

The ratios are presented below with the marginal and cumulative R^2 values, the regression coefficients and the predicted signs.

Ratio	Marginal R-squared	Cum. R-squared	Regr. Coeff.	Pred. Sign
Working Capital Turnover	.15104	.15104	.1059	+
Debt Ratio	.03271	.18375	1.7088	−
Current Debt Ratio	.05747	.24122	.3587	−
Receivables Turnover	.03445	.27567	−.0100	+
Current Asset Ratio	.02185	.29752	.5874	+
Profit Margin	.03366	.33118	.0862	−
Return on Equity	.02280	.35398	−.0458	−
Cash Ratio	.01351	.36749	−.0225	+
Current Ratio	.00523	.37272	.3015	+
Debt to Equity Ratio	.02284	.39556	−.6255	−
Total Asset Turnover	.00745	.40301	.1487	−
Quick Ratio	.01172	.41473	−.0750	+
Plant Asset Turnover	.01256	.42729	−.0732	−
Inventory Turnover	.00257	.42986	.0060	−
Current Debt Ratio	.00174	.43160	−.6727	−
Working Capital Ratio	.00089	.43249	−.0634	+

From the above list it can be seen that only seven of the coefficients have signs that match the predicted signs. All of the categories included (capital investment was not included) are represented and only one of the ratios that could have been included, return on assets, was excluded by the program. The overall model explains 43.2 percent of the variability in the slope of the price reduction curve. It must be remembered however that the capital investment ratios, all of which were statistically significant in year 2, were not included.

F. DESCRIPTION OF MODELS

After the stepwise regression was completed several models were tried by heuristically controlling the variables placed into the regression analysis. These variables were chosen by using the results of the stepwise analysis and by observing the correlation results. The criteria for selecting variables to enter the models were:

1   A model should be constructed with the minimum number of ratios possible.

2.   Each of the categories of ratios should be represented.

3.   If more than one ratio from a category was to be used the pairwise correlation between those two ratios should be less than .50.

The factors used to evaluate the models included the R^2 values, the adjusted R^2 values, the F-statistic value and its level of significance, and the t-ratios for each of the variables in the model and their level of significance.

Many different models were attempted with various combinations of five, six, seven, and eight variables. The results varied widely. The model described below was the best model found. The R-squared, adjusted R-squared and the F-statistic were the highest of all models tried. In addition, the t-ratios of the individual variables were, as a group, the best observed.

The model is described by the equation:

$$slope = -1.196 + .0169X_1 + .5396X_2 + .5683X_3 + .0216X_4 + .0106X_5 + .3011X_6 + .5653X_7$$

where:

	t	sig t
X_1 = Investment to Assets	18.007	.0000
X_2 = Debt Ratio	8.155	.0000
X_3 = Current Assets Ratio	5.352	.0001
X_4 = Inventory Turnover	5.669	.0001
X_5 = Return on Equity	2.449	.0293
X_6 = Working Capital Turnover	17.541	.0000
X_7 = Current Ratio	9.947	.0000

The statistical values obtained for evaluation of this model were:

R^2 = .97055
Adjusted R^2 = .95470
F-statistic = 61.213
Significance of F = .0000

A problem with the signs is seen with this model. Only three of the seven signs for the coefficients in the equation match what was predicted, (investment to assets, current assets ratio and current ratio). This is consistent with the correlation analysis. However, this model explains a significant portion (97%) of the variability in the dependent variable, the slope of the price reduction curve.

Of the ratios with the matching signs, the capital investment ratio was by far the most important and significant variable in explaining price reduction slopes. The findings are consistent with the hypothesis that firms that are investing most heavily in new plant and equipment are motivated to adopt penetration strategies to increase the likelihood of the new capacity being employed. The two short term liquidity ratios, current ratio and current assets ratio, also carry the predicted signs in the model. This is consistent with the hypothesis that firm's with a poor liquidity position will prefer skimming, which will provide profits in the near term to cover shortages in short term funds resulting from introduction of a product.

Of the ratios that appear in the model without the predicted sign, the profitability ratio is perhaps the easiest to explain. The profitability ratios showed the weakest relation to the price reduction curve throughout the study. Defense contractors have

been characterized as profit satisfiers, rather than profit maximizers. [Ref. 15;pp. 217-221] The weakness of the correlation seen here may be a further demonstration of the legitimacy of that characterization. In the case of the two asset utilization ratios, it may be that defense firms experiencing low asset utilization are motivated to use skimming as a means to generate funds required to keep design teams and production facilities intact while pursuing further government contracts. Firms that are near full capacity may be less concerned with further U.S. government contracts and therefore prefer penetration as a marketing tool to attract Foreign Military Sales buyers. No reasonable explanation can be offered for the positive debt ratio in the model.

Two of the categories of financial ratios are represented by two ratios in this model. They are short term liquidity (cash ratio and current ratio) and asset utilization (inventory turnover and working capital turnover). The pairwise correlation between the current assets ratio and current ratio is .4378 and between inventory turnover and working capital turnover is .2347. Both pairwise correlations meet the previously stated criteria of pairwise correlations not greater than .5 for inclusion in the model.

G. FACTOR ANALYSIS AND REGRESSION

Because of the potential for interrelationships among the variables (ratios) a factor analysis was attempted to try to control for the interrelationships. A regression analysis was then run using the factors derived.

All 21 variables were initially placed into the factor analysis. The resulting factor matrix was sufficiently confused so that no meaning could be attached to any of the factors. For this reason a varimax rotation was run for the factor analysis. The rotated matrix for the 21 variables listing the coefficients is shown in Table 8. The factors selected with their eigen values, marginal and cumulative percents of variance are listed below:

Factor	Label	Eigen Value	Pct of Var	Cum Pct
1	Capital investment	6.32906	30.1	30.1
2	Solvency	5.81736	27.7	57.8
3	Profitability	2.37906	11.3	69.2
4	Asset Utilization	2.00806	9.6	78.7
5	Current to total assets	1.40512	6.7	85.4
6	Short term liquidity	1.13640	5.4	90.8

The labels are subjectively applied. The only "pure" factor is factor 3, profitability, which contains all three profitability ratios and no others. The capital investment ratios grouped together in factor 1, along with receivables turnover, and the solvency ratios are all included in factor 2 with the current ratio. The remaining ratios are scattered among factors 4 through 6. The new term

TABLE 8

ROTATED FACTOR MATRIX

Ratio	Factor Number 1	2	3	4	5	6
Investment to assets	.965	-.005	.115	-.203	-.133	-.059
Investment to plant assets	.957	.054	.940	-.164	-.138	.029
Investment to funds	.943	.093	-.122	-.208	-.013	-.166
Investment to sales	.907	.071	.164	-.201	-.252	.031
Receivables turnover	-.894	.189	-.174	-.190	-.078	.163
Debt ratio	.041	.943	-.227	.003	-.040	.049
Current debt to equity	-.075	.927	-.273	-.038	.047	-.095
Current debt ratio	.052	.892	-.149	.229	-.073	-.219
Debt to equity	-.078	.884	-.298	-.144	.057	.019
Current ratio	-.157	-.750	.043	-.247	.518	.125
Return on equity	.107	-.304	.904	.051	-.041	.016
Return on assets	.105	-.403	.886	.006	.021	.060
Profit margin	.118	-.160	.885	-.314	-.039	-.008
Working capital turnover	-.248	.262	-.070	.836	-.307	-.122
Total assets turnover	-.258	-.097	-.157	.832	.030	.360
Current assets ratio	-.158	.033	-.058	-.062	.920	.029
Working capital ratio	-.056	-.590	.035	-.234	.643	.332
Plant assets turnover	-.194	.028	-.036	.625	.638	.208
Quick ratio	.116	-.205	.085	.132	.216	.909
Inventory turnover	-.343	.120	-.021	.307	-.149	.622
Cash ratio	-.272	-.272	-.007	-.172	.358	.543

"current to total assets" was used for factor 5 because of the three ratios in that factor, two were from the short term liquidity category and both used total assets in the denominator of the raw ratio. Short term liquidity was then applied to factor 6 because the two ratios from that category, quick ratio and cash ratio, measure the most liquid of the current assets.

The factor scores were calculated from the factor analysis program and were used in the regression analysis. This resulted in the regression model described by the equation:

$$\text{slope} = .248 - .030X_1 + .010X_2 + .041X_3 + .188X_4 + .119X_5 + .159X_6$$

where:

		t	sig t
X_1 = factor 6		-1.491	.1619
X_2 = factor 1		1.832	.0918
X_3 = factor 4		1.064	.3082
X_4 = factor 2		2.566	.0247
X_5 = factor 3		2.559	.0250
X_6 = factor 5		2.367	.0356

The statistical values obtained for this model were:

R^2 = .51480
Adjusted R^2 = .27220
F-statistic = 2.122
Significance of F = .1260

These results are not very significant. One problem with the factor analysis is the problem of missing values. Even with pairwise treatment of missing values, only 19 programs were used for the

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analysis. This clearly limits the acceptability of the factor analysis in this instance. With more of the programs available for the analysis it is felt that the results perhaps would have been different.

H. SUMMARY

An attempt was made to develop a regression model that could serve as a predictor for the slope of the price reduction curve. In doing this correlation analysis, stepwise regression, observation of the data and factor analysis processes were used. The best result was the development of the seven variable model which possessed an R-squared value of .9706. This indicates a strong relationship between the slope of the price reduction curve and the financial condition of a company, as compared to the financial condition of the industry as a whole.

The problem experienced with the resulting signs not matching the predicted signs remains problematic. This indicates that the hypothesized relationships between financial condition categories and the price reduction curve cannot, in general, be supported. More research is obviously needed.

VI. CONCLUSIONS, OBSERVATIONS AND RECOMMENDATIONS

A. CONCLUSIONS

It is the researcher's conclusion that there is an identifiable relationship between corporate financial condition and the slope of the price reduction curve for products in the DoD aerospace industry. This relationship was seen most strongly when financial condition was measured by financial ratios compared against the industry averages for the third year prior to program start. The relationship that was found was quantified in a seven variable linear regression model that had an R-squared value of .971, an adjusted R-squared value of .955 and an F-statistic of 61.2.

B. OBSERVATION

Since this study is a follow-on to two previous studies on the same subject it is worthwhile to compare the results. The earliest study was the McGrath/Moses study [Ref. 4] referred to in Chapter II. That study utilized a smaller database than the more recent studies but did result in substantial convincing evidence that measures of risk and asset utilization are factors influencing contractor pricing strategy.

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The Johnstone/Keavney study [Ref. 12] utilized essentially the same database as the present study. The results of their analyses were inconclusive compared to the McGrath/Moses study and they concluded that:

> While there was occasional evidence of significant relationships between financial ratios and price reduction slopes, those relationships were not consistently significant over time. [Ref. 5:pp. 66-67]

The best model from each of the studies is listed in Table 9 for comparison. The current study appears to document most strongly a statistical relationship between financial condition and pricing strategy. In particular, the positive aspects of the current study are:

1. That a high statistical association between the ratios and the price reduction curve is found.

2. That a small number of ratios explains a large portion of the variance in the slope of the price reduction curve.

3. That a greater percentage of the variance has been explained than was possible in previous studies.

The negative aspect of the current study is that the signs of the coefficients of the relationships were not consistent with the expectations. Therefore, the original hypotheses were not, in general, consistently supported. Recall that negative signs were expected for profitability, solvency and asset utilization. Positive signs were expected for short term liquidity and capital investment.

In the correlation analysis signs were mixed.   In the regression

model developed, the signs were all positive.

C. RECOMMENDATIONS

1. That the year 2 seven variable model be validated further
    with different sample populations from the DoD aerospace
    industry.

2. That the basic methodology be tested in other segments of the
    defense acquisition market; including ship construction,
    armored vehicles, major electronics, etc.

3. That the study be repeated using other bases for comparison
    against the corporate financial ratios.

TABLE 9

COMPARISON OF FINANCIAL CONDITION/PRICING STRATEGY MODELS

McGrath/Moses model

$$\text{slope} = .7745 + .0469X_1 + .0075X_2 - .3042X_3 + .0007X_4 - .0051X_5 + .1350X_6$$

where:

X_1 = current ratio	F-value	5.29
X_2 = receivable turnover	Sig. F	.004
X_3 = current debt ratio	R^2	.665
X_4 = interest coverage	Adj. R^2	.539
X_5 = inventory turnover		
X_6 = investment to funds		

Johnstone/Keavney model

$$\text{slope} = .94 - 1.55X_1 - .0008X_2 + .06X_3 - .03X_4$$

where:

X_1 = return on assets	F-value	3.40
X_2 = receivable turnover	Sig. F	.0737
X_3 = total assets turnover	R^2	.not given
X_4 = investment to funds	Adj. R^2	.3445

TABLE 9 (CONTINUED)

Webb model

$$\text{slope} = -1.196 + .0170X_1 + .5396X_2 + .5683X_3 + .0216X_4 + .0106X_5 + .3011X_6 + .5653X_7$$

where:

X_1 = investment to assets	F-value	61.213
X_2 = debt ratio	Sig. F	.0000
X_3 = cash ratio	R^2	.97055
X_4 = inventory turnover	Adj. R^2	.95470
X_5 = return on equity		
X_6 = working capital turnover		
X_7 = current ratio		

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